A texture-enhancement procedure for separating orchard from forest in Thematic Mapper data

DANIEL K. GORDON† and WARREN R. PHILIPSON

CLEARS, Cornell University, Hollister Hall, Ithaca, New York 14853, U.S.A.

Abstract. A procedure is described for automatically separating temperate fruit tree orchards from mixed deciduous forest in LANDSAT Thematic Mapper data. A filter is applied to enhance the texture of bands 4 and 3 prior to ratioing, smoothing, and level-slicing to a binary image on the basis of supervised training. Including the binary image in supervised classification of single date imagery has reduced misclassification of forest as orchard from 75 per cent of the forest pixels to fewer than 7 per cent.

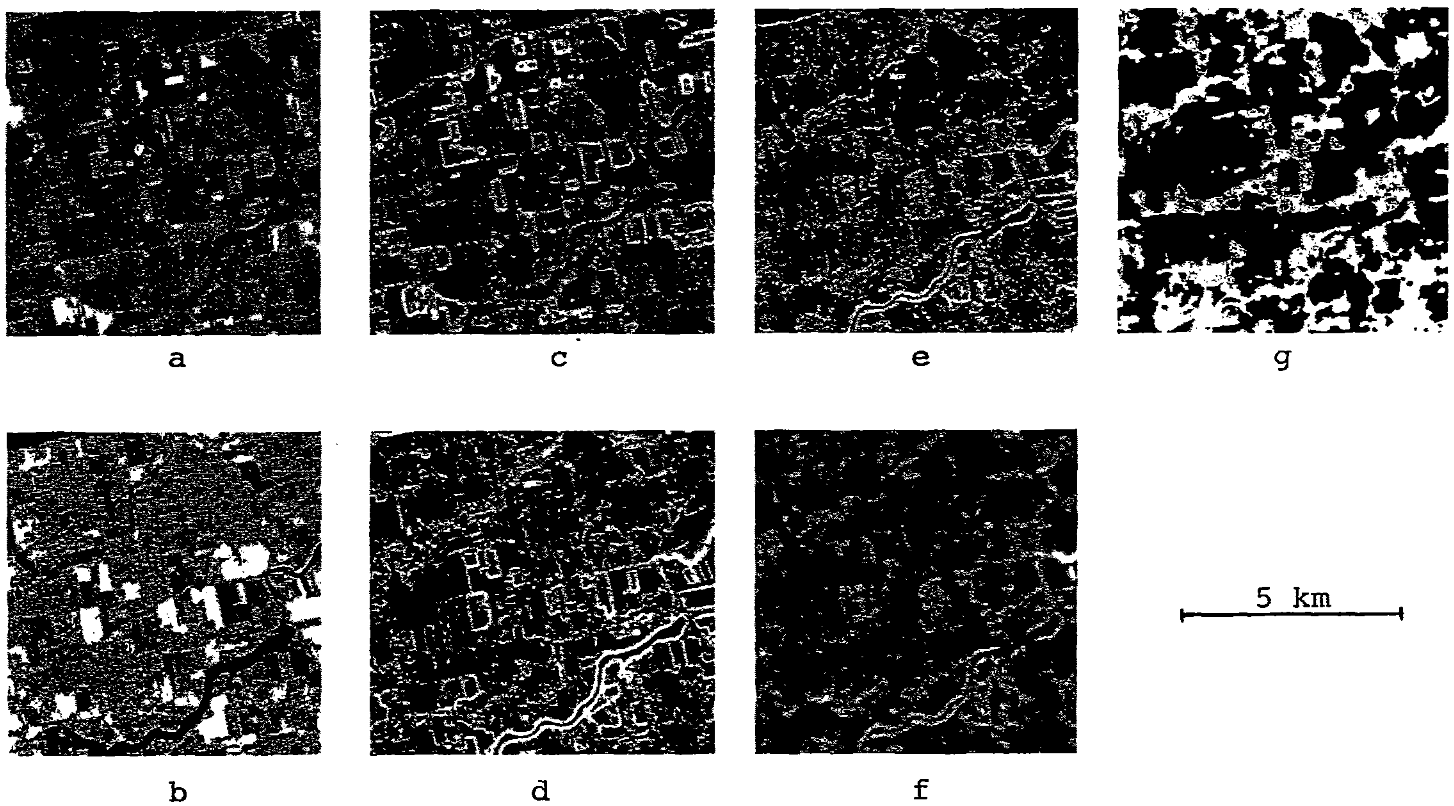
1. Introduction

In an investigation of the feasibility of applying LANDSAT Thematic Mapper (TM) data for inventorying fruit trees (apple, cherry, pear, peach) in New York State, it became apparent that a reliable approach was needed for automatically distinguishing orchards from mixed deciduous forest (Gordon 1985). Spectrally, there is much overlap between the two cover types, especially when the orchards are mature. Fortunately, however, the two do in fact differ in their texture, particularly in TM band 4 (near-infrared, 0·76–0·90 μm) and to a lesser extent in TM band 3 (red, 0·63–0·69 μm).

Due to orchard row spacing (7–13 m), each 30 m TM pixel of a specific orchard contains a comparable number of trees, resulting in a relatively low level of spectral variation among pixels throughout that orchard. In contrast, the mixture of tree species common to deciduous forests and their high-reflectance in the near-infrared produce a much higher variation than that of orchards in TM band 4. In TM band 3, the effect is reversed. While orchards still do not exhibit a high level of spectral variation, the overall reflectance of vegetation is low in band 3. Minor changes within the mix of orchard trees and background are sufficient to produce reflectance differences which exceed those produced by the diffferent forest tree species, whose absorption of light by leaf chlorophyll is apparently quite uniform.

The application of algorithms for enhancing textural differences has been documented (e.g. Haralick 1979, Haralick and Fu 1983). This communication describes the texture-enhancement procedure that was developed for separating temperate zone fruit tree orchards from mixed deciduous forest.

† Present address: Autometric, Inc., Falls Church, Virginia, U.S.A.



Thematic mapper images illustrating steps for separating orchard from forest. (*a*) and (*b*) bands 3 and 4, respectively, (*c*) and (*d*) texture-enhanced bands 3 and 4, respectively; (*e*) ratio of texture-enhanced band 4/texture-enhanced band 3; (*f*) twice-smoothed version of (*e*); (*g*) binary image, with white being non-orchard (forest) and black being orchard, plus.

2. Procedure

The procedural outline is described as follows.

Step 1. Enhance the difference in spectral variation between orchard and forest

This is accomplished by passing a 3×3 pixel filter over the TM image. The centre pixel in the output image is assigned the sum of the absolute differences between the centre pixel and each of its eight surrounding pixels in the input image. For reasons discussed, the filter is applied to images of bands 3 and 4 (figure (*a*)–(*d*)).

Step 2. Reduce the effects of edge pixels

After step 1, those pixels occurring along the edges of spectrally different fields (e.g. orchard versus field crops) will be anomalously bright in both bands (figure (*c*) and (*d*)). To darken edges common to both texture-enhanced bands, the two texture-enhanced bands are ratioed, 4/3 (figure (*e*)).

Step 3. Reduce within-class variation

Ratioing of the texture-enhanced images will have the effect of increasing variation within the forest and orchard. In an effort to reduce this variation, a smoothing filter is passed over the ratioed image. A 3×3 pixel filter assigns the average of the nine pixels in the input image to the centre pixel of the same 3×3 pixel window in the output image. For the New York study, the best results were obtained when the filter was applied twice—passing the filter a second time over a once-filtered ratioed image (figure (*f*)).

Step 4. Produce a binary image of 'non-orchard' and 'orchard plus'

As a final step prior to classification, the twice-smoothed, ratioed, texture-enhanced image is level-sliced to a binary image (i.e. black and white with no grey shades). Pixels above or equal to a certain threshold grey value are set to 255 (white), and those below the threshold are set to 0 (black). With the band 4/band 3 ratio, white pixels will be non-orchard, including forest, and black pixels will be orchards along with other non-forest vegetative cover types (figure (*g*)).

The threshold grey value is selected on the basis of training with representative orchards as would be done in supervised classification. Best separation of orchards from forest has been obtained by choosing the threshold to encompass 95 per cent of all orchards from the training. Setting the threshold higher (e.g. to include 99 per cent of all orchards) places too many forest pixels on the orchard side of the threshold.

3. Conclusion

When the binary image is included in a supervised maximum likelihood classification of six bands of single date TM imagery, misclassification of forest as fruit tree orchards has been reduced from as many as 75 per cent of the forest pixels to fewer than approximately 7 per cent. When the binary image is included with other multi-date TM bands in supervised classification, misclassification of forest pixels has been reduced to fewer than 1 per cent of the pixels. This latter step and classification accuracies are discussed by Gordon (1985) and will be described in a longer communication.

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